

WHAT IS CLAIMED IS:

- 1 1. An apparatus for treating a patient comprising:
2 an expandable body having a proximal end, a distal end, a longitudinal axis
3 therebetween, and at least one microstructure having an attached end attached to the body and
4 a free end in an undeployed position along the expandable body,
5 expansion of the body creating forces which deploy the at least one
6 microstructure from the undeployed position to a deployed position wherein the free end
7 projects radially outwardly from the expandable body.
- 1 2. An apparatus as in claim 1, wherein the at least one microstructure has
2 a directional axis between the free end and the attached end, and wherein the directional axis
3 extends along the longitudinal axis while the at least one microstructure is in the undeployed
4 position.
- 1 3. An apparatus as in claim 1, wherein the at least one microstructure has
2 a directional axis between the free end and the attached end, and wherein the directional axis
3 extends across the longitudinal axis while the at least one microstructure is in the undeployed
4 position.
- 1 4. An apparatus as in claim 1, wherein the free end has a pointed shape.
- 1 5. An apparatus as in claim 4, wherein the pointed shape includes a single
2 point, a multiple point, an arrow shaped point including a pointed tip and at least one
3 undercut, or a combination of these.
- 1 6. An apparatus as in claim 1, wherein the free end has a flat-edged
2 shape.
- 1 7. An apparatus as in claim 1, further comprising a material carried by the
2 at least one microstructure, wherein the material is delivered to the patient by the at least one
3 microstructure.
- 1 8. An apparatus as in claim 7, wherein the material comprises at least a
2 gene, at least a drug or a combination of these.

1 9. An apparatus as in claim 7, wherein the material is coated on a surface
2 of the at least one microstructure.

1 10. An apparatus as in claim 7, wherein the material is held in a lumen
2 within the at least one microstructure.

1 11. An apparatus as in claim 1, wherein the expandable body comprises an
2 endoluminal stent.

1 12. An apparatus as in claim 11, wherein the stent is sized for positioning
2 within a vascular lumen.

1 13. An apparatus as in claim 11, wherein the stent is configured to
2 maintain the deployed position and remain in the lumen.

1 14. An apparatus as in claim 1, wherein the expandable body is retractable
2 to the undeployed position.

1 15. An apparatus as in claim 1, wherein the expandable body is comprised
2 of shape-memory alloy, stainless steel, titanium, tantalum, vanadium, cobalt chromium alloy,
3 polymer, or a combination of these.

1 16. An apparatus for treating a patient comprising:
2 a radially expandable body having a proximal end, a distal end, a longitudinal
3 axis therebetween, and a plurality of microstructures, each microstructure having first and
4 second supports and a free end, the supports affixed to associate first and second adjacent
5 portions of the radially expandable body,
6 expansion of the expandable body within the patient effecting relative
7 movement between the associated first and second portions of the expandable body,
8 the relative movement deploying the microstructures from an undeployed
9 position along the expandable body to a deployed position with the free end projecting
10 radially outwardly from the expandable body.

1 17. An apparatus as in claim 16, wherein the at least one microstructure
2 has a directional axis between the free end and the associate first and second adjacent

3 portions, and wherein the directional axis extends along the longitudinal axis while the at
4 least one microstructure is in the undeployed position.

1 18. An apparatus as in claim 16, wherein the at least one microstructure
2 has a directional axis between the free end and the associate first and second adjacent
3 portions, and wherein the directional axis extends across the longitudinal axis while the at
4 least one microstructure is in the undeployed position.

1 19. An apparatus as in claim 16, wherein the microstructures extend
2 radially a distance of between 25 µm and 5000 µm from the radially expandable body.

1 20. An apparatus as in claim 16, wherein the free end has a pointed shape.

1 21. An apparatus as in claim 20, wherein the pointed shape includes a
2 single point, a multiple point, an arrow shaped point including a pointed tip and at least one
3 undercut, or a combination of these.

1 22. An apparatus as in claim 16, wherein the relative movement of the
2 associated first and second portions of the expandable body comprises circumferential
3 movement of the first portion relative to the second portion when the expandable body
4 expands radially.

1 23. An apparatus as in claim 22, wherein the associated first and second
2 portions are in circumferential alignment and the circumferential movement of the first
3 portion relative to the second portion draws the free end toward the circumferential
4 alignment.

1 24. An apparatus as in claim 22, wherein the circumferential movement
2 pulls the affixed ends of the first and second supports apart which moves the free end.

1 25. An apparatus as in claim 24, the radially expandable body further
2 comprising an interior lumen along the longitudinal axis configured for receiving an
3 expandable member which expands the expandable body, wherein the movement of the free
4 end creates friction against the expandable member as the expandable member expands the
5 expandable body, the friction projecting the free end radially outwardly.

1 26. An apparatus as in claim 24, the radially expandable body further
2 comprising an interior lumen along the longitudinal axis configured for receiving an
3 expandable member which expands the expandable body, wherein expansion of the
4 expandable body by the expandable member pulls the affixed ends of the first and second
5 supports apart which torsionally deforms the first and second supports projecting the free end
6 radially outwardly.

1 27. An apparatus as in claim 24, wherein the radially expandable body is
2 self-expanding composed and the self-expansion of the expandable body pulls the affixed
3 ends of the first and second supports apart which torsionally deforms the first and second
4 supports projecting the free end radially outwardly.

1 28. An apparatus as in claim 16, wherein the first and second supports
2 comprise elongate shafts extending between the free end and the associated first and second
3 adjacent portions of the radially expandable body.

1 29. An apparatus as in claim 28, wherein the relative movement of the
2 associated first and second portions of the expandable body comprises moving the associated
3 first and second portions apart so that the supports pull the free end in opposite directions
4 causing the free end to project radially outwardly.

1 30. An apparatus as in claim 28, wherein the elongate shafts are adjacent
2 to each other and aligned with a circumference of the expandable body in the undeployed
3 position.

1 31. An apparatus as in claim 16, wherein each microstructure further
2 comprises a third support affixed to an associated third portion of the radially expandable
3 body, the associated first and third portions being connected so as to move in unison.

1 32. An apparatus as in claim 31, wherein the first, second and third
2 supports comprise elongate shafts attached to the free end and to the associated first, second
3 and third adjacent portions of the radially expandable body, respectively, and wherein the
4 second support is disposed longitudinally between the first and third supports.

1 33. An apparatus as in claim 32, wherein the relative movement of the
2 associated first and second portions of the expandable body comprises moving the associated

3 first and second portions apart while the associated third portion moves in unison with the
4 associated first portion, so that the supports pull the free end in opposite directions forming a
5 tripod structure which projects the free end radially outwardly.

1 34. An apparatus as in claim 1, wherein the at least one microstructure
2 comprises a plurality of microstructures disposed near the proximal end and/or the distal end
3 and not therebetween.

1 35. An apparatus as in claim 1, wherein the at least one microstructure
2 comprises a plurality of microstructures disposed between the proximal and distal ends and
3 not substantially near the ends.

1 36. A system for treating a patient comprising:
2 an expandable body having a proximal end, a distal end, and at least one
3 deployable microstructure, wherein expansion of the body deploys the at least one
4 microstructure to project radially outward from the expandable body; and
5 a material carried by the at least one microstructure, wherein the material is
6 delivered to the patient by the at least one microstructure.

1 37. A system as in claim 36, wherein the material is coated on a surface of
2 the at least one microstructure.

1 38. An apparatus as in claim 36, wherein the at least one microstructure
2 includes a lumen and the material is held in the lumen.

1 39. An apparatus as in claim 38, wherein the expandable body further
2 includes a delivery microsystem and the material is delivered to the lumen from the delivery
3 microsystem.

1 40. An apparatus as in claim 39, wherein the delivery microsystem
2 includes a therapeutic delivery control device which delivers the material to the lumen at
3 predetermined intervals.

1 41. An apparatus as in claim 40, wherein delivery is triggered by an
2 external signal in the form of a radiofrequency signal, an injectable chemical signal, an
3 ultrasonic signal or a combination of these.

1 42. A system as in claim 36, wherein the material comprises at least a
2 gene, at least a drug or a combination of these.

1 43. A system as in claim 42, wherein the material comprises a gene
2 encoding for nitric oxide synthase or vascular endothelial growth factor.

1 44. A system as in claim 42, wherein the material comprises prednisone,
2 low molecular weight heparin, low molecular weight hirudin, Rapamycin/Sirolimus,
3 Paclitaxel, Tacrolimus, Everolimus, Tyrphostin AG 1295, CGS-21680 Hydrochloride, AM
4 80, Estradiol, Anti-sense compounds, E2F Decoys, or a combination of these.

1 45. A system as in claim 42, wherein the material comprises DNA and an
2 adhesive material to which DNA adheres.

1 46. A system as in claim 42, wherein the material comprises a
2 biocompatible material which provides a protective coating to the drugs and/or genes.

1 47. A method of treating a patient comprising the steps of:
2 providing an expandable body having a proximal end, a distal end, a
3 longitudinal axis therebetween and at least one microstructure having an end attached to the
4 body and a free end;
5 positioning the expandable body within a vessel of the patient, wherein the at
6 least one microstructure is in an undeployed position; and
7 expanding the body within the vessel so that forces are created which deploy
8 the at least one microstructure, the free ends of the deployed microstructures projecting
9 radially outward from the expandable body.

1 48. A method as in claim 47, further comprising expanding the body so
2 that the deployed at least one microstructure penetrates the vessel wall.

1 49. A method as in claim 48, wherein the body comprises a stent and
2 penetration of the vessel wall anchors the stent within the vessel.

1 50. A method as in claim 48, wherein the wall of the vessel comprises an
2 intimal layer, a medial layer and an adventitial layer, and wherein expanding the body
3 penetrates the free end through at least the intimal layer.

1 51. A method as in claim 50, wherein expanding the body penetrates the
2 free end through at least the medial layer.

1 52. A method as in claim 47, wherein expanding the body comprises
2 inflating a inflatable member within the body so as to increase its cross-sectional diameter.

1 53. A method as in claim 47, wherein the body is self-expanding and
2 expanding the body comprises releasing the body to allow self-expansion.

1 54. A method as in claim 47, wherein the at least one microstructure
2 carries a material and further comprising delivering the material to the patient.

1 55. A method as in claim 54, further comprising expanding the body so
2 that the deployed at least one microstructure penetrates the vessel wall, wherein the material
3 is coated on a surface of the at least one microstructure and delivering the material comprises
4 transferring the material from the surface of the at least one microstructure to the penetrated
5 vessel wall.

1 56. A method as in claim 54, further comprising expanding the body so
2 that the deployed at least one microstructure penetrates the vessel wall, wherein the material
3 is held in a lumen within the at least one microstructure, and delivering the material
4 comprises injecting the material into the penetrated vessel wall.

1 57. A method as in claim 54, wherein the material comprises at least a
2 gene, at least a drug or a combination of these.

1 58. A method for treating a patient comprising the steps of:
2 providing an expandable body having a proximal end, a distal end, and at least
3 one deployable microstructure carrying a material;
4 positioning the expandable body in an undeployed position within a vessel of
5 the patient;
6 expanding the body to a deployed position within the vessel, wherein
7 expansion of the structure deploys the at least one microstructure to project radially outward
8 from the expandable body;
9 penetrating a wall of the vessel with the at least one microstructure; and

10 delivering the material from the at least one microstructure to the wall of the
11 vessel.

1 59. A method as in claim 58, wherein the material is coated on a surface of
2 the at least one microstructure and delivering the material comprises transferring the material
3 from the surface of the at least one microstructure to the penetrated vessel wall.

1 60. A method as in claim 58, wherein the material is held in a lumen
2 within the at least one microstructure, and delivering the material comprises injecting the
3 material into the penetrated vessel wall.

1 61. A method as in claim 58, wherein the material comprises at least a
2 gene, at least a drug or a combination of these.

1 62. A method as in claim 58, wherein expanding the body comprises
2 inflating a inflatable member within the body so as to increase its cross-sectional diameter.

1 63. A method as in claim 58, wherein structure is self-expanding and
2 expanding the structure comprises releasing the structure to allow self-expansion.

1 64. An apparatus for treating a patient comprising:
2 an expandable body having an inner ring and an outer ring surrounding a
3 longitudinal axis; and
4 at least one microstructure, each microstructure having first and second
5 supports and a free end, the first support affixed to the inner ring and a second support affixed
6 to the outer ring,
7 expansion of the expandable body within the patient effecting relative
8 movement between the inner ring and the outer ring,
9 the relative movement deploying the at least one microstructure from an
10 undeployed position to a deployed position with the free end projecting radially outwardly
11 from the expandable body.

1 65. An apparatus as in claim 64, wherein the first and second supports are
2 rotateably connected near the free end.

1 66. An apparatus as in claim 64, wherein the microstructures extend
2 radially a distance between 25 μm and 5000 μm from the radially expandable body.

1 67. An apparatus as in claim 64, wherein the free end has a pointed shape.

1 68. An apparatus as in claim 67, wherein the pointed shape includes a
2 single point, a multiple point, an arrow shaped point including a pointed tip and at least one
3 undercut, or a combination of these.

1 69. An apparatus as in claim 64, further comprising a material carried by
2 the at least one microstructure, wherein the material is delivered to the patient by the at least
3 one microstructure.

1 70. An apparatus as in claim 69, wherein the material comprises at least a
2 gene, at least a drug or a combination of these.

1 71. An apparatus for treating a patient comprising:
2 an expandable body having a proximal end, a distal end, a longitudinal axis
3 therebetween, and at least one microstructure having an attached end attached to the body and
4 a free end in an undeployed position,
5 the at least one microstructure deployable by rotation of the free end radially
6 outwardly from the expandable body.

1 72. An apparatus as in claim 71, wherein the expandable body has an outer
2 surface and wherein the attached and free ends are aligned with the outer surface in the
3 undeployed position.

1 73. An apparatus as in claim 71, wherein the expandable body has an inner
2 lumen and the at least one microstructure has a protruding region between the attached end
3 and the free end which protrudes into the inner lumen, the at least one microstructure
4 deployable by applying a force to the protruding region from within the inner lumen.

1 74. An apparatus as in claim 73, wherein the at least one microstructure is
2 deployable by applying force radially outwardly against the protruding region.

1 75. An apparatus as in claim 74, wherein the at least one microstructure is
2 deployable by applying force radially outwardly against the protruding region by expansion
3 of an expandable member within the inner lumen.

1 76. An apparatus as in claim 73, wherein the protruding region forms an
2 angle between the attached end and the free end.

1 77. An apparatus as in claim 71, wherein the attached end is attached to the
2 body by a rotateable joint.

1 78. An apparatus as in claim 71, further comprising a material carried by
2 the at least one microstructure, wherein the material is delivered to the patient by the at least
3 one microstructure.

1 79. A method of treating a patient comprising the steps of:
2 providing an expandable body having a proximal end, a distal end, a
3 longitudinal axis therebetween, an inner lumen and at least one microstructure having an end
4 attached to the body, a free end and a protruding region therebetween which protrudes into
5 the inner lumen;
6 positioning the expandable body within a vessel of the patient, wherein the at
7 least one microstructure is in the undeployed position; and
8 applying a force against the protruding region from within the inner lumen
9 which deploys the at least one microstructure to a deployed position wherein the free ends of
10 the deployed microstructures project radially outwardly from the longitudinal axis.

1 80. A method as in claim 79, wherein applying a force against the
2 protruding region comprises expanding an expandable member against the protruding region.

1 81. A method as in claim 80, wherein the expandable member comprises
2 an inflatable member.

1 82. A method as in claim 79, wherein applying a force against the
2 protruding region rotates the free end around the attached end.

1 83. A method as in claim 79, further comprising expanding the body so
2 that the deployed at least one microstructure penetrates the vessel wall.

1 84. A method as in claim 83, wherein expanding the body comprises
2 inflating an inflatable member within the body so as to increase its cross-sectional diameter.

1 85. A method as in claim 79, wherein the at least one microstructure
2 carries a material and further comprising delivering the material to the patient.

1 86. A method as in claim 85, wherein the material comprises at least a
2 gene, at least a drug or a combination of these.